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ABSTRACT

A study on effects of learning physics in English and in Spanish on achievement differences was conducted with two groups of Latin American freshmen students enrolled at the University of Texas, respectively, in 1969 and 1970. The learning materials were categorized into units, and each group was divided into two subgroups. While one of the 1969 subgroups learned a unit in Spanish, the other subgroup learned the same unit in English. For the 1970 group, one subgroup learned all units in Spanish and the other, in Spanish and English, alternately. Comparisons were made among the achievement test scores of the four subgroups. For the 1970 group, the scores on an aptitude test in Spanish and an English ability test were also used for covariance analysis and served as predictors. Results obtained showed that the group taught partially in English did not demonstrate a significant improvement in general ability with English over the group taught entirely in Spanish. A great deal of exposure to English was possible for the Latin American student without significant risk to physics achievement grades. Total and verbal scores on entrance tests were good predictors of success in physics. (CC)

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Teaching Physics In Spanish to Latin American Students*

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Since the fall of 1968, the Physics Department of The University of Texas at El Paso has been engaged in the teaching of physics in Spanish to students from Latin America. The physics classes are part of a general program whose purpose is to encourage students from Latin America to pursue science routes. The program was designed to allow first year students to take all of their course work (including physics) in Spanish, and at the same time allow them to take an intensive course on the English language. This research deals mainly with the effects of learning physics in Spanish on physics achievement. It tries to find any differences in achievement in the mentioned group of students when learning physics in Spanish and when learning physics in English. Saying it another way, it tries to determine how much English can be used in the physics classroom without affecting physics achievement. The author taught all classes involved in the experiment. The student population included only first year students from Latin America (mainly Mexico) pursuing routes of engineering, chemistry, or physics.

In the fall of 1969, 40 students from Latin America enrolled in the author's class. The total group was subsequently divided into two

SE 015 910

matched groups by means of a series of entrance exams. The two groups were taught by the author using materials developed by him in English and then translated into Spanish. The materials included reading material, laboratory write-ups, and testing instruments. The two groups were to be exposed to six units incorporating these materials. However, each of the groups would be learning in Spanish half of the time and in English half of the time. The experimental design is shown in Table I. Note that while one group was learning in Spanish the other group was learning in English.

Table I. Experimental Design 1969

Units	1	2	3	4	5	6
Group A	Span	Eng	Span	Eng	Span	Eng
Group B	Eng	Span	Eng	Span	Eng	Span

The 1969 experiment was analyzed by comparing the scores on the achievement tests given at the end of each unit. The results of this analysis is shown in Table II.

Table II compares the scores of the tests taken in English to the scores of the tests taken in Spanish for the students in Group A. It then does the same thing for the scores of Group B. Finally, it compares the scores of <u>all</u> the tests taken in English from both groups to all of the tests taken in Spanish from both groups.

Table II. Comparison of English and Spanish Test Scores (1969)

	Group A	Group B	Group A + B
Mean: English scores	32.39	33.17	32.78
Mean: Spanish scores	35.28	34.83	35.06
t	2.26	1.44	2.60
Level of significance (p)	<0.05	>0.05	0.02

Choosing 0.05 as the level for significance for this analysis (and all subsequent analyses), Table II shows a significant difference between the Spanish scores and the English scores of Group A. In the case of Group B, no significant difference appears. When the groups were combined, there is a significant difference in the test scores.

In the fall of 1970, the 1969 experiment was repeated with some modification. Two new units were added, giving a total of eight, and Group B, as shown by Table III, was taught entirely in Spanish.

Table III. Experimental Design 1970

Units	1	2	3	4	5	6	7	8
Group A	Span	Eng	Span	Eng	Span	Eng	Span	Eng
Group B	Span	Span	Span	Span	Span	Span	Span	Span

Since in this study no effort was made to match the two groups, two entrance exam scores, the PAA (Prueba de Aptitud Academica, a test in Spanish similar to SAT), and a test of English ability were used to perform analysis of covariance and thus allow for group differences in both general ability in physics and command of English.

Tables IV and V show the analysis of the 1970 data. In this case, the test scores from Units 2, 4, and 6, from Group A, were compared to the scores from the same units of Group B. This was done in order to compare learning in English to learning in Spanish.

Table IV. Comparison of English and Spanish Test Scores Using PAA Scores as Covariable (1970)

	Covariable		Criterion		
Group	Mean	Sigma	Mean	Sigma	Adjusted Means
A	1242.13	157.86	41.25	6.07	40.62
B	1164.69	177.88	37.63	7.45	38.26
	F = 1.00		p > 0.05		

Table V. Comparison of English and Spanish Test Scores Using English Test Scores as Covariable (1970)

	Covariable		Criterion		
Group	Mean	Sigma	Mean	Sigma	Adjusted Means
A	125.56	23.23	41.25	6.07	41.08
B	98.31	29.66	37.63	7.45	37.79
	F = 1.35		p > 0.05		

The results of Tables IV and V show no significant difference in the means of the scores when adjusted for group differences in PAA scores of English ability scores. That is, the groups scored as well on achievement tests on the Spanish units as they did on the English units. In this case, the test for significance was one for uncorrelated means, since the scores from Group A were compared to the scores from Group B. This test was inherently less sensitive than the one performed in 1969.

With the 1970 design, an attempt was made to find out if the group learning partially in English (Group A, Table III) would show a significantly different improvement with English ability from the improvement of the group learning totally in Spanish (Group B, Table III). The analysis was made by giving an alternate form of the English entrance exam after completion of the eight units. The results are shown in Table VI. The columns labelled "gains" represent the difference between the means of the pre and post test scores for each group.

The combined score for the aural and written test (see Table VI) shows an improvement of 12.38 points for Group A (out of a total of 140) and an improvement of about 11.00 points for Group B. The difference between these means does not reach a significant level. This is, Group A did not improve in English ability significantly over Group B.

Because of the various entrance exams given to the Latin American students in 1970, it was possible to use these test scores to establish predictors of success in physics. This is, it was possible to look for correlations between physics grades and grades on the entrance exam

Table VI. Comparison of Gains in English Ability

Test	Gain (Group A)	Gain (Group B)	Significance of Difference of Gain (p)
Aural	6.63	3.81	>0.05
Written	5.81	7.75	>0.05
Aural + Written	12.38	11.00	>0.05

scores. These entrance exams consisted of the following: a translated version of COOP Physics Achievement Test, the PAA test in Spanish, Test of Aural Comprehension, the English Language Test, and an algebra test used by this institution.

Table VII shows a correlation matrix for all of the entrance exam scores (Columns 1 through 8) and final grade in physics (Column 9). The final grade in physics was rated on a 1 to 4 scale (F to A). The scores are labelled as follows:

PAA (V) = verbal score on PAA test

PAA (M) = mathematics score on PAA test

PAA (T) = total score on PAA test

ENG (A) = score on aural English test

ENG (W) = score on written English Language Test

ENG (T) = combined score of aural and written English tests

Table VII. Correlation Matrix

	PAA (V)	PAA (M)	PAA (T)	ENG (A)	ENG (W)	ENG (T)	Entrance Math	Entrance Physics	Physics Grade
$\bar{x}$	567.0000	636.4062	1203.4062	65.9062	46.0312	111.9375	39.7187	18.0312	2.9375
σ	105.5432	81.8149	172.5710	18.9083	14.1829	29.9238	13.6410	4.3767	1.3214
	1	2	3	4	5	6	7	8	9
1	1.0000	0.6918	0.9396	0.1240	0.4158	0.2754	0.1925	0.5578	0.4688
2	0.6918	1.0000	0.8972	0.2305	0.4302	0.3495	0.2452	0.6580	0.3772
3	0.9396	0.8972	1.0000	0.1851	0.4582	0.3341	0.2340	0.6531	0.4655
4	0.1240	0.2305	0.1851	1.0000	0.6279	0.9295	-0.0824	0.0722	0.0160
5	0.4158	0.4302	0.4582	0.6279	1.0000	0.8707	-0.1477	0.2824	0.0218
6	0.2754	0.3495	0.3341	0.9295	0.8707	1.0000	-0.1221	0.1794	0.0204
7	0.1925	0.2452	0.2340	-0.0824	-0.1477	-0.1221	1.0000	0.2483	0.3874
8	0.5578	0.6580	0.6531	0.0722	0.2824	0.1794	0.2483	1.0000	0.3732
9	0.4688	0.3772	0.4655	0.0160	0.0218	0.0204	0.3874	0.3732	1.0000

The results of Table VII show that the single best predictor of final physics grade is the PAA (V) score; the correlation coefficient is 0.4688 between these two variables. PAA (T) is next in order giving a correlation coefficent of 0.4655 with physics grade. Table VIII gives the significance of all the correlation coefficients in the matrix. It shows that PAA (V) and PAA (T) are significant at the 0.01 level.

Table VIII. Significance of Correlation Coefficient Between Physics Grade and Variables Shown

Variable		r	p
SAT (V)		0.47	0.01
SAT (M)		0.38	0.05
SAT (T)		0.47	0.01
ENG (A)		0.02	>0.05
ENG (W)		0.02	>0.05
ENG (T)		0.02	>0.05
Entrance	Math	0.39	0.05
	Physics	0.37	0.05

In summary, it can be said that if differences in physics achievement exist in the two learning situations described (first two experiments), they are small, and can be detected only with sensitive statistical techniques. Stating this differently, a great deal of exposure to English is possible, in a physics class for the mentioned population, without significant risk to the achievement grades. This result indicates that the language is not such an important factor when technical material is being covered. The next to last study shows that although there was improvement in general ability with English in both groups, the group taught partially in English did not show a significant improvement over the group taught entirely in Spanish. This result

might be expected, since the vocabulary used in physics is rather special and might not be reflected in a test of general ability. The last study indicates that verbal scores and total scores on entrance tests similar to the SAT are good predictors of success in physics, when the tests are given in Spanish to the group described.

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